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The Wonders of Discovery

Reviving Interest in Natural History

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Dharma Lane (right) captures specimens for nature study as part of a Junior Naturalist program for children age eight-to-twelve.

PHOTO/GRACE BEAHM

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S.C. Sea Grant Consortium
287 Meeting Street
Charleston, S.C. 29401
phone: (843) 953-2078
e-mail: Annette.Dunmeyer@scseagrant.org

Executive Director
M. Richard DeVoe

Director of Communications
Susan Ferris Hill

Editor
John H. Tibbetts

Art Director
Pam Hesse
Pam Hesse Graphic Design

HANDS-ON LEARNING. *Dori-Lynn Coburn (left) and Beth Burkett of the Charleston County Park and Recreation Commission teach a Junior Naturalist class at Beachwalker Park on Kiawah Island.*
PHOTO/GRACE BEAHM

The Wonders of Discovery

Reviving Interest in Natural History

by John H. Tibbetts

On a hot September morning, young nature explorers are handling small crabs and snails from the beach and shallow surf at Beachwalker Park on Kiawah Island. Age eight-to-twelve, they are enrolled in the Junior Naturalist program sponsored by the Charleston County Park and Recreation Commission.

The youngsters gather around their teacher, Beth Burkett, a natural-history interpreter, who draws a side-view of a fish in the sand: two smooth, curving lines that intersect at the head and tail.

"Does anyone know why fish look this way?" asks Burkett.

Hands shoot up.

A boy says: "Aerodynamic!"

Smiling, Burkett nods. He means "hydrodynamic." Correct principle; wrong classical element, which is no matter.

Gabby and excited, the kids follow their teacher to the tideline to find more creatures to handle and wonder over.

The Junior Naturalist program is a small part of a nationwide effort to renew America's distinguished tradition of natural history, bringing students of all ages back to the study of nature.

That won't be easy. Children are spending extraordinary amounts of time with their smartphones, tablets, computers, televisions, and other screens. By 2010, young people were spending an average of 7½ hours per day, seven days a week, with recreational media, according to a 2010 study by the Kaiser Family Foundation.

Parents complain that children aren't experiencing real moments in real places. Are we losing our young people to the digital world?

A generation ago, American kids used to go outside to play. They had plenty of unstructured, unsupervised time, especially during summer vacations and after school. When towns and cities were more compact, the countryside was nearer at hand. On summer mornings, youngsters could go

crabbing or hunting, returning home for a quick lunch, and heading back out again. The goal was to stay outside until the last light.

As a small boy in the 1930s, Edward O. Wilson, the most celebrated and influential naturalist of our time, discovered the outdoors at Paradise Beach on the eastern shore of Perdido Bay on the Florida Panhandle.

"Each morning after breakfast," he writes in his 1994 autobiography, "I left my small shorefront house to wander alone in search of treasures along the strand. I waded in and out of the dependably warm surf and scrounged for anything I could find in the drift . . . A child comes to deep water with a mind prepared for wonder."

Wilson saw beautiful creatures: "bottlenose porpoises" arcing rhythmically over the water. And he saw homely creatures: the Gulf toadfish, a bottom-dwelling fish with "a huge mouth, bulging eyes, and slimy skin."

His lazy days set the stage for his life's work. "I was seven years old, and every species, large and small, was a wonder to be examined, thought about, and, if possible, captured and examined again."

Wilson added: "Hands-on experience at the critical time, not systematic knowledge, is what counts in the making of a naturalist . . . Better to spend long stretches of time just searching and dreaming."

Rachel Carson, the naturalist and author of *Silent Spring*, often took children to the seashore. The heightened senses and emotions of children allow for intense connections to nature. "The years of childhood are the time to prepare the soil" for the seeds of natural-history knowledge to grow, she wrote.

Students of natural history learn the science of classification: how to recognize species, put them into a hierarchical scheme, and understand them in broader ecological contexts of relationships and habitats.

Some naturalists have found their life's work in youthful solitary explorations, just as Wilson did. Others are introduced to nature by teachers, older friends, and family members.

Edward O. Wilson, America's most influential contemporary naturalist, examines plant gall.
PHOTO/CORBIS

"I had a great aunt, a biology professor, who took me outside a lot and fostered an interest," says Burkett, the instructor for the junior naturalists. "I think you'll find that most folks interested in natural history had someone like that, a mentor who gave them structure but also freedom to explore on their own."

Modern parents, though, worry about unsupervised kids running off to the woods or waterside. Also, traditional outdoor avocations—hunting and fishing—have lost much of their role in American family life after large stretches of the countryside emptied out following World War II. Many children, as a result, aren't learning about nature on their own or from experienced guides.

Still, Torry Monroe, of West Ashley, takes his daughter Riley, age 10, on deer hunts, and encourages her to get involved in the Junior Naturalist program.

"I wanted my daughters to get into the outdoors early," says Monroe, "so that would keep them from getting into trouble later on. From looking at little crabs on the beach to deer hunting, Riley's interested."

Today's busy families plan shorter vacations that replace, say, a two-week summer trip visiting national parks and camp sites with briefer, less immersive jaunts.

Per capita visits to the national park system are down since the mid-1980s. In a recent report, the National Parks Second Century Commission blames this decline on "competition from other recreation activities (including sedentary activities among youth)." The report adds: "Our children and young adults seem to have lost touch with nature and history to an unprecedented degree." The author Richard Louv coined a phrase for this loss of emotional and intellectual experience of natural places: "nature deficit disorder."

As the noonday sun beats down on Kiawah Island, the young naturalists are herded to a shaded pavilion where they will finish lessons for the day.

Linda Geronilla, a volunteer who splits her time between the lowcountry and West Virginia, is beaming after her morning with youngsters. She's learning more about the natural world, too.

"I want to be able to answer my grandchildren when they come up to me and say, 'What kind of crab is this?' If I can't answer the questions, then I'll know where to go for answers. I see how busy my kids are with their jobs, but I have time."

Geronilla takes part in the Charleston Master Naturalist Program sponsored by Charleston County Park and Recreation Commission and Clemson University Extension Service. (Two other lowcountry regions—Winyah Bay and the Beaufort area—have similar programs.) Participants learn how to "read" the natural world of organisms and habitats, developing an understanding of ecological relationships. After a 13-day course, the students can become certified as master naturalists.

Many participants are older, perhaps retired or empty-nesters. Some have jobs as guides for outfitters and other nature-based tourism businesses and want more knowledge, according to Kristina Wheeler, a natural-history interpreter who co-instructs the program in Charleston County.

There are similar master-naturalist programs in 27 other states, and several more states are developing new ones.

While amateur ranks are growing, the number of professional naturalists has been shrinking for decades. Specimen collections in natural-history museums and other institutions have been consolidated or allowed to languish for lack of funding. Taxonomists are retiring, but they aren't being replaced. Taxonomists collect, identify, and name species, analyzing the evolutionary relationships among them. Their collections are libraries of life, which can go to waste without knowledgeable curators.

Greater biological riches could be found if there were more taxonomists to find them. As many as 13 million species of plants, animals, and microorganisms are living today. But taxonomists have only identified and named approximately two million so far. Now scientists warn of further extinction crises driven by climate change and habitat destruction.

"We've been losing species before we even knew what they were," says David Knott, a Charleston-based consulting biologist for natural-resource agencies.

Yet natural history appears to be making a comeback, at least in amateur circles. The smartphone—a sensor with a camera, clock, and GPS—is fueling thousands of "citizen science" projects in which volunteers gather bulk observations for scientific research. This is also sometimes called "crowd-source science."

A growing number of serious amateurs are using smartphones to photograph and identify wildlife species, sending pictures and other data to websites where their observations can be confirmed and added to digital libraries of biodiversity. Birders, for instance, are using new smartphone apps to identify and document where particular bird species are finding food and nesting sites.

Volunteers are observing species of mammals, mollusks, finfish, fungi and lichen, kelp and diatoms, and many other creatures. Beachcombers are on the lookout for king tides. Boaters document abandoned vessels and marine debris. Weather enthusiasts monitor precipitation in their backyards. And a growing number of scientists and resource managers are using such data to monitor changes in the environment.

"We're seeing more people come back into the environment so they can experience it directly while also bringing their technologies—their smartphones and apps," says Elizabeth Vernon Bell, marine education specialist for the S.C. Sea Grant Consortium. "It's not one or the other—the environment or technology. It's a marriage of both."

EARLY NATURALISTS

Until the late 19th century, nearly all of the people involved in science were amateurs and earned their keep by other means. Many were physicians. Some had wealthy or royal patrons. Others enjoyed inherited wealth. Then there were explorers who made their living primarily as artists or writers.

Botany was the dominant natural-history discipline during the European age of exploration. European empires eager for new crops searched to uncover plant species and varieties. And since European medicine was based largely on herbalism, physician-naturalists hunted plants that could remedy health maladies.

In the late 17th and early 18th centuries, settlers encountered a new biological world in subtropical Carolina. They sent dried plants and other biological specimens to collectors in the Old World. Collectors solicited specimens from lowcountry planters, merchants, ship captains, physicians, and even slaves and Native Americans.

Explorers reported on herbal medicines used by native peoples who lived within or near the southern colonies of British North America. After his 550-mile travels through Carolina and beyond, explorer John Lawson in 1709 expressed his admiration for native plant treatments that could cure "Burns beyond Credit," pox, and ulcers. Lawson noted that white planters often consulted Native Americans and their use of

PERCEPTIVE. *To be a naturalist, you must closely observe the world—like Isabel Bucheit does, poring over bird feathers in a nature-study class.*
PHOTO/GRACE BEAHM

Carl Linnaeus in a 1775 painting by Alexander Roslin.
PHOTO/WIKIPEDIA

"Spontaneous plants."

In the mid-18th century, Carl Linnaeus, a Swedish physician-naturalist, invented a new technique of organizing plant species: the sexual system. He identified and named species according to the number of stamens, the male parts, and the number of pistils, the female parts. (Later naturalists improved upon his system.) A novice could look at a representation of a species in a book or drawing and one in hand to check whether there was a match.

Guided by Linnaean taxonomy, European collectors expanded their treasures of specimens, illustrations, and descriptions of species. They sought specimens of flora and fauna from colonial settlements and native peoples fanned across the New World. Students of Linnaeus spread out too, exploring uncharted regions—that is, uncharted by Europeans—and sent him dried plants and other specimens for him to identify.

This process was similar to today's crowd-sourcing of science. Many contributors to 18th century natural history worked remotely and sent their data to skilled "natural philosophers," as scientists were called. (The term "scientist" was invented in the 1830s.)

The most ambitious of the 18th century South Carolina naturalists was a Scottish physician named Alexander Garden (1730-1791) who arrived in the colony in 1752, hoping that a warmer climate would relieve a lung ailment. Proud, prickly, and intelligent, Garden set up a practice in Charleston and became known as a lowcountry expert in Linnaean taxonomy. While he used slaves to gather specimens and acquired medicinal plants from knowledgeable local natives, he was contemptuous of his fellow white South Carolinians for their botanical ignorance.

Garden shipped his specimens to Ellis who passed them on to Linnaeus, who was impressed. Linnaeus named the Cape jasmine the "Gardenia" and eventually credited Garden for describing three new genera of plants, two new genera of fish, and 60 new species of serpents, insects, and fish.

A naturalist in Garden's era would commonly ask himself a series of questions when encountering an unfamiliar organism. He (they were almost always men) would look closely at the organism and scan his memory, thinking of whether he'd ever seen it before. Perhaps, yes—but where? And when? And in what locations? How many times?

Did the organism's features coincide with descriptions in other naturalists' conversations, correspondence, printed descriptions, or illustrations? Did it already have a name in the known taxonomy? Could it be an already recognized species that's traveled outside of its familiar habitat? Or could this organism be a new species to science?

The same questions are asked today. The structure of natural history continues to be expressed in a series of steps: first, the immediate observing of an organism; second, the naturalist rifling through her personal memories; and, third, the naturalist musing over the insights of fellow seekers of knowledge in their correspondence, conversations, images, books, field guides—and now computer databases.

Natural history still depends on people observing nature and accurately communicating what they've found over time and space. Natural history continues to be a far-flung enterprise of the curious who take advantage of observational and communication tools of the moment.

For centuries, the tools of natural history included pen, ink, paper, and mail delivery.

Today a naturalist's tools also include broadband connectivity and the smartphone, the technologies so apparently indispensable to contemporary American life and commerce.

NEW DIGITAL TOOLS

Imagine walking through a lowcountry wild place and spying a wading bird land in the shallows of a freshwater swamp. Is that a wood stork (*Mycteria americana)*?

You can photograph it with your smartphone, which has a built-in GPS, and send the pictures and your location to iNaturalist, a web-based application acquired in 2014 by the California Academy of Sciences, which had already been using this platform in citizen-science programs.

You've now made an observation—the "what, where, and when" of finding something in nature. The app does much of the work for you, automatically tagging your observation with a date, time, and GPS coordinates.

"I used iNaturalist the last time I was traveling and birding through the beautiful coastal regions of South Carolina," says amateur birder Frank Marenghi, a shellfish biologist at the Maryland Department of Natural Resources.

"I have my spatial information associated with my pictures," says Marenghi, "so I can see exactly where I was when I saw the Swainson's Warbler or the territorial pair of Painted Buntings." He can keep track of all his observations with iNaturalist maps and calendars, which is easier than taking field notes on paper. He also notes flowering times and insect emergence and includes them with

INSTANT I.D. *Achi Treptow, a wildlife biologist with S.C. Department of Natural Resources, photographed an unfamiliar plant at Dungannon Plantation Heritage Preserve south of Charleston. With his smartphone, he posted the photo on a new iNaturalist website dedicated to observations in a growing number of South Carolina's heritage preserves and wildlife management areas. Treptow asked for help identifying the plant, and iNaturalist curators quickly responded, agreeing that it was a club moss (Lycopodiaceae family).*
PHOTOS/GRACE BEAHM

photos in the iNaturalist database.

"You can get feedback from many other users of iNaturalist," says Achi Treptow, a wildlife biologist with S.C. Department of Natural Resources. "You might have an expert in the field agree with your observation or you might have someone else disagree with you. Either way, everyone involved in the process is learning."

Identification records at iNaturalist that pass muster with curators are shared with the Global Biodiversity Information Facility (GBIF), an international open data infrastructure funded by governments.

GBIF holds data of more than 1.5 million species collected over three centuries of natural-history exploration, including recent observations by citizen scientists, researchers, and automated monitoring programs.

Soon the GBIF will extend its reach by linking to the Census of Marine Life, a global effort completed in 2010. This census effort created the Ocean Biogeographic Information System, a massive online repository of ocean-related data, all referenced by geographic location.

The combined effort could provide access to searchable information about species from the deep ocean to coastal areas to mountaintops around the world.

Participants in this new citizen science include fishermen, hunters, birders, hikers, beachcombers, park rangers, scientists, and many others.

"I applaud iNaturalist and bird counts," says Rudy Mancke, who teaches natural history at the University of South Carolina and is the best-known naturalist in the state. Sharing what you know with others, he says, is fun and leads to an understanding of the natural world. "If you understand something, you take better care of it, and that's conservation."

In fact, the U.S. conservation movement emerged from the growing popularity of bird counts, which, of course, relied on volunteers' skill in recognizing species.

Bird counts were organized in reaction to hunting excesses of the 1880s and 1890s. American women were embracing the fashion trend of wearing hats decorated with brilliant feathers from water birds, wading birds, and seabirds. To gain these plumes, commercial hunters decimated tern, heron, gull, and egret rookeries along the entire Atlantic coast from the tip of Florida to the northern coast of Maine.

A group of Massachusetts women, outraged by the slaughter, gathered to organize for reforms in the millinery trade. They called their new group the Audubon Society, which set out to protect nesting colonies of non-game

114 YEARS AND COUNTING. *Birdwatchers have historically been among the most dedicated naturalists and citizen scientists. Paul Koehler (right), director of Silver Bluff Audubon Center and Sanctuary, and Mackenzie Keohane participate in the Audubon Society's Christmas Bird Count, which has provided valuable data for more than a century.*
PHOTOS/GRACE BEAHM

birds devastated by the millinery trade.

The Audubon Society effectively lobbied Congress to pass laws prohibiting people from killing or capturing birds except under strict hunting and permit regulations.

Some recreational hunters shifted to watching birds, and the term "bird-watching" was born. In 1900, the ornithologist Frank Chapman established an annual Christmas Bird Count, providing a bird-watching alternative to the Side Hunt, a Christmas tradition in which hunters competed to see how many birds and other animals they could shoot.

The Christmas Bird Count is the longest-running citizen-science project in the world. Held annually from December 14 through January 5, the Christmas Bird Count has helped scientists track trends in bird populations on two continents.

In 2013-2014, more than 63,000 volunteers participated across North and South America. The National Audubon Society today lists more than 200 published studies that have depended in part on data from its Christmas bird count. The Cornell Lab of Ornithology, collaborating with Audubon, has created an all-year smartphone app for amateur birders called eBird, one of the oldest—and considered among the best—of the new observational tools.

If there's a common weakness across citizen science, it's the problem of volunteers gathering inaccurate data. Volunteers, of course, have varying levels of skill in observation. Smartphone technologies, though, can help to improve accuracy. Today, some 3,000 citizen-science projects around the country are sending their observations to iNaturalist to be verified by online curators.

The iNaturalist project is also valuable for hobby naturalists who think they see something unusual in the woods.

"Someone goes into the woods and claims he's seen Bigfoot, while someone else [in the same location] instead sees a bear," says Scott Loarie, an environmental scientist and co-director of iNaturalist. "Now we tell people, 'The next time you think you see Bigfoot, take a picture of it and share it with the community at iNaturalist who can tell whether or not it really is Bigfoot.' " Or just a bear.

Josh Tewksbury, an ecologist on leave from the University of Washington and director of a conservation institute in Switzerland, is excited about the potential for citizen science.

"People are really good at image recognition, much better than computers," he says. "That's what our brains are made to do." Still, many scientists

"are a little slow in trusting" crowd-sourced data from citizen science.

Members of major birding groups are known for their strong organization skills, knowledge of natural history, scrupulous data gathering, and passion for conservation. That's why numerous scientists have relied on data from Audubon's Christmas Bird Count, for instance.

But many other volunteer groups might not have the birders' dedication, experience in the field, and knowledge of their study subjects. So it's wise for researchers to make citizen science as uncomplicated as possible.

Often the best crowd-sourced data can be gained, Tewksbury says, "when volunteers are organized on a single task on a particular day and given clear instructions on how to perform just that one special task."

EDUCATION AND NATURAL HISTORY

Between the 1910s and World War II, natural history was an important element in the curriculum of many American schools.

Anna Botsford Comstock published a hugely successful textbook in 1911 for elementary students and teachers called *Handbook of Nature-Study*. Comstock and other textbook writers of the time promoted direct contacts between children and living organisms. Teachers were encouraged to take kids outside on field trips and see nature up close.

Anna Botsford Comstock.
PHOTO/LIBRARY OF CONGRESS

ESSENTIAL RESEARCH. *Dennis Allen, director of the University of South Carolina's Baruch Marine Field Laboratory in Georgetown County, and his colleagues have collected more than 30 years of natural-history data at North Inlet, including tiny estuarine species like copepods.*
PHOTO/GRACE BEAHM

But by the 1950s, Comstock's "nature-study" was being replaced by the science lecture. A teacher would talk for an hour and then assign homework that called for memorizing facts, vocabulary, and formulas. Field trips and classes became less frequent. In many schools they vanished.

Yet K-12 science education has changed a lot since the mid-1990s. More emphasis now is placed on students learning scientific concepts through hands-on experiments. South Carolina science standards primarily focus on STEM skills—science, technology, engineering, and math—that can prepare students for jobs after graduation. Unfortunately, natural history can get left behind unless teachers make an effort to include it.

Schoolteachers have long been a bulwark of natural history in this country. Today, nearly every decent-sized American town has at least one teacher-naturalist leading public nature walks and pointing out the best bird-watching spots or places to collect butterflies.

Natural history in higher education, by contrast, has precipitously declined over the past half-century.

Dennis Allen, director of the University of South Carolina's Baruch Marine Field Laboratory, and his colleagues have built one of the few long-term records of natural-history data for East Coast estuaries. At North Inlet in Georgetown County, Allen and his team have collected more than 30 years of data on water temperature, zooplankton, and juvenile fish, shrimps, and crabs.

It remains tough, he says, to cobble together funding each year to continue sampling efforts and analyzing data. Natural history is not where the big grant money is.

"Natural history is almost a lost science," says Allen. "So few people above the high-school [teaching] level have a genuine interest in it. Yet a fundamental understanding of natural

history is essential for interpreting and responding to long-term changes in ecosystems and natural resources. And we have a whole lot more to learn."

After World War II, academic biology shifted decisively away from natural history and long-term studies of whole organisms—tree swallows, ant colonies, or terrapins—in their environments. Instead, biologists became far more likely to study a single characteristic or part of an organism such as its molecular or genetic structure in the laboratory.

Edward O. Wilson, the great naturalist, watched this revolution play out firsthand.

In his 1994 autobiography, Wilson recalls his new colleague James Watson, co-discoverer of the structure of DNA, at Harvard University in the 1950s:

"[Watson] arrived with a conviction that biology must be transformed into a science directed at molecules and cells . . . What had gone before, 'traditional' biology—*my* biology—was infested by stamp collectors who lacked the wit to transform their subject into a modern science."

Naturalists lost out to specialists in the "new biology"—genetics, molecular biology, cell biology—who made scientific advances in medicine, public health, agriculture, and many other new disciplines and reshaped the world.

Ecology also shifted away from field studies to computer modeling. "We cannot get big grants to do field work anymore," laments Reed Noss in the journal *Conservation Biology* in 1996. "Computer modeling produces publishable results quicker anyway."

Conservation biologists have increasingly become "indoor" scientists, writes Noss. Biologists are rewarded for supervising research projects, writing grants, and traveling to conferences. That's where they might have the most influence in their field, potentially affecting how natural resources are managed.

So natural history—the traditional biology—increasingly seemed old-fashioned, costly, and time-consuming, an enterprise that largely belonged to the past. Many scientists have argued that they could best learn about organisms by studying molecules and genes.

"The naturalist's methods were seen as oriented to the field and the museum, as descriptive and qualitative in form," said David J. Schmidly, a biologist and former president of Oklahoma State University, in a 2004 speech. Natural history became a "derogatory" term.

Still, natural history hung on after the 1960s. Biology majors were required to take a course or two on natural history in many colleges and universities. Naturalists would offer general field classes and courses dedicated to identifying and understanding the life histories of various groups of organisms: invertebrates, birds, flowering plants, lichens, mammals, fungi, insects, and so on.

But those courses have quietly disappeared. Natural history has been dropped from required biology curricula in the majority of U.S. colleges and universities, a recent survey shows. A typical biology graduate likely won't need to take a single course in identifying species and writing accurate field notes.

THE COMEBACK OF NATURAL HISTORY?

Edward O. Wilson is the public face of modern natural history in somewhat the same way that Stephen Hawking is the public face of theoretical physics. Over the past half-century, Wilson made his scientific reputation by studying ants and his fame by writing award-winning books about biodiversity, evolution, and conservation.

Wilson is optimistic about natural history's future. Biologists have already begun integrating natural history with other disciplines to understand the entire gamut of life from molecule to cell to organism to ecosystem to the planet. "Humanity," Wilson argues, "desperately needs a more extensive and integrated biology."

This integrated biology can be found in fights against infectious diseases that have emerged from other animal hosts: avian influenza, SARS (Severe Acute Respiratory Syndrome), Lyme disease, hantavirus, West Nile virus, and rabies.

TACTILE EXPERIENCE. *A wharf crab* (Sesarmidae *family) is the subject of study by Junior Naturalists on Kiawah Island.*
PHOTO/GRACE BEAHM

No one, however, has pinned down Ebola's "natural reservoir"—the animal species that carries the dormant pathogen during lulls between human outbreaks. Scientists are looking for the Ebola virus in wild animals that people hunt in the bush and eat. If this hidden virus pool could be located, that would help scientists understand how to eradicate it. Trained workers could go into the bush to test, isolate, and kill infected wild animals, removing them as a human food source and limiting their capacity to transmit the virus to people.

Managing such infectious diseases requires interdisciplinary teams with training in natural history, medicine, microbiology, and many other fields.

The knowledge of an animal host's life history—where it lives, what it eats, what preys upon it—has been critical in predicting and controlling the spread of diseases, reducing infection rates, and saving lives.

"Scientists working across disciplines such as natural history and human health—that is the future of science," says Tewksbury, the director of a conservation institute in Switzerland. "And we'll see this more and more."

But we're not encouraging the coming generations of professional naturalists—not in K-12, not in higher education, not in job opportunities, and not in mentoring or role models.

Edward O. Wilson's role models were the naturalist-entomologists whose generation preceded his own. They spent their careers learning everything they could about a group of insects—bees, butterflies, or ants. His heroes returned again and again to the field, but they also learned what other scientists were discovering or had discovered in the past.

Their "passion was the science of classification," Wilson writes, "but they also ventured beyond, to the ecology of their chosen subjects, to anatomy, to life cycles, to evolutionary relationships, to behavior."

Wilson italicizes his admiration in terms of touch, both physical and intellectual: "*Each had a feel for the organism*—and that is what mattered."

DATA COUNTS. ***Volunteers on Sullivan's Island keep track of debris items collected during the 2014 Beach Sweep/River Sweep.***
PHOTO/SUE TUTTLE, VOLUNTEER/NATIONAL PARK SERVICE

Which brings us back to the junior naturalists on Kiawah Island who handled small fish and crabs and other organisms they found on the beach, learning as children so often do—by physical discovery, by touching and peering closely at creatures.

If we hope to develop scientists who can find life-saving knowledge from the natural world, we must relearn how to understand the natural world firsthand.

Teachers could incorporate more natural history into their already tightly packed schedules, argues Jennifer Frazer, a blogger for *Scientific American*. University professors should encourage the teaching of natural history and field science and make them requirements for a biology degree at their institutions.

If you're a scientist who is stuck in your lab or office laboring over grant proposals, she writes, you could take time to go back into the field and rediscover the organisms you study.

And each of us could take some kids out for nature walks. Bring along a field guide and a smartphone, look and listen, and take some pictures. It might be easier than ever to find a community of fellow seekers, to learn and share your knowledge of the natural world.

Naturalists keep watch over biological invasions

Scientists see growing evidence that climate change is altering the range of many wild organisms, including aquatic species that have recently arrived in the Carolinas for the first time.

Naturalists are keeping watch over changes in ranges of numerous species. The methods of field monitoring and taxonomy—natural history—allow scientists to locate, track, and understand non-native species and their impacts from place-to-place.

David Knott, a Charleston-based consulting biologist for natural-resource agencies, has documented more than 65 non-native invertebrate species that have moved into South Carolina freshwater and saltwater ecosystems over the past three decades, though none has shown to be a nuisance. Of the 65 species, 13 are freshwater, 48 are brackish to marine, and four are semi- or fully-terrestrial in nature.

Nine of those 65 species expanded their range to South Carolina from regions to the south partly because of warming waters here, says Knott.

A much larger fraction of those 65 new species in South Carolina were originally introduced to tropical areas of the western North Atlantic from other tropical regions around the world.

"The non-natives became established in waters to our south and have gradually, or in some cases abruptly, moved into South Carolina," says Knott. "That dispersal may be attributed to [warmer] temperatures that allow those species to creep north until they reach the limit of their current tolerance range."

Climate conditions, in other words, appear to allow some non-native species that have gained a niche in regions to the south—the eastern coast of Florida, the Caribbean, and the Gulf of Mexico—to stretch their range northerly, moving into the Carolinas.

As a non-native species moves into a new habitat, it can become invasive and out-compete natives for food and other resources. Or the non-native species might have left behind predators that kept its population under control in its former habitat. As a result, the non-native species population can grow very rapidly.

The red lionfish (*Pterois volitans*) is one example of that problem. The invasive red lionfish, originally a native of the Indo-Pacific region, has expanded its range from eastern Florida farther north to the Carolinas, following the warm Gulf Stream. This range expansion could be influenced by climate change, scientists say.

The red lionfish has been called the most invasive reef species in the world, gobbling up prey that are unfamiliar with its hunting techniques. This fish has become a hugely abundant and destructive predator in the western Atlantic and the Caribbean.

Some non-native species arriving from locations farther south, however, haven't yet survived South Carolina's winter temperatures.

In 2006, a non-native, tropical green mussel (*Perna viridis*) was found in South Carolina for the first time. The green mussel is a saltwater pest that invaded Florida thousands of miles from its Asian native habitat in coastal waters along the Persian Gulf to Hong Kong.

Green mussels grow large; they are hand-size at full maturity. In Florida, they have proliferated in dense layers on marine facilities and boats. Their accumulated weight has sunk navigational buoys and floating docks. Colonies of the mussel have clogged water intakes in Florida power plants.

But not long after the mussel arrived in South Carolina, it died off because of cold winter events, especially during the winter of 2009-2010, and did not return.

That especially cold winter also dramatically knocked back populations of two other tropical marine invertebrates that had invaded South

PROLIFIC PREDATOR. ***The invasive red lionfish (Pterois volitans), originally a native of the Indo-Pacific region, has expanded its range, following the Gulf Stream from eastern Florida north to the Carolinas. But climate change also could be influencing this range expansion, scientists say.***
PHOTO/GRACE BEAHM

Carolina: the green porcelain crab, *Petrolisthes armatus*, and the titan acorn barnacle, *Megabalanus coccopoma*. These two species have apparently not returned in significant numbers to South Carolina.

But will their populations expand again in South Carolina as the ocean warms?

That could depend on the intensity of winter cold extremes along the coast. Bitterly frigid weather appears to be the limiting factor for the northerly expansion of some tropical species.

The number of very cold days in South Carolina's coastal waters has increased in frequency since the early 1990s, although average annual temperatures have been rising over the same period, scientists say. These winter cold snaps are largely driven by a long-term trend in ocean circulation—called the North Atlantic Oscillation—that drives Arctic blasts southward, scientists say.

But are these cold extremes in the region also enhanced by climate change? Could global warming somehow help drive Arctic blasts farther south along the Atlantic coast? Scientists are trying to answer those questions.

SALTWATER NUISANCE. ***In 2006, the non-native, tropical green mussel (Perna viridis) was found in South Carolina for the first time but soon disappeared during subsequent cold winters. As climate change accelerates, though, the green mussel could move into South Carolina again.***
PHOTO/WADE SPEES

Yet there are fewer and fewer professional naturalists with hard-won observational skills and experience to track non-native species and spread alarms when those species become biological invaders.

"We need more people who know which native species are out there," says Knott. "If you don't know which species are native, then you can't recognize which species don't belong there and could become invasive. If you can't recognize invasive species early, you can't control them early."

Reading and Websites

CCPRC Junior Naturalist program. **www.cprc.com/2051/Junior-Naturalist-Program**

Clemson Extension S.C. Master Naturalist program. **www.clemson.edu/public/naturalist**

Global Biodiversity Information Facility. **www.gbif.org**

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NEWS & NOTES

Shellfish conference panel explores link between climate change and oyster disease

Many regions around the world have lost their oyster resources to overharvesting, disease, pollution, or salinity changes, but the South Carolina coast has managed to sustain its fishery and oyster populations better than most. The state, moreover, has successfully restored many oyster beds with new techniques and knowledge.

Now, though, an expanding threat to oyster fisheries is emerging as coastal waters warm because of climate change, according to a panel presentation at the 16th International Conference on Shellfish Restoration, December 10-13, 2014, in Charleston.

The U.S. conference is a biennial event that brings together researchers, industry figures, regulators, coastal advocates, and others. The idea is to see "what's been working and what hasn't been working in shellfish management and restoration around the world," said Rick DeVoe, executive director of S.C. Sea Grant Consortium, which organized the conference.

Over 200 attendees participated in conference sessions, which included practices of restoring shellfish ecosystems, rehabilitation of shellfish populations, and protection and improvement of water quality for shellfish survival, growth, and harvest.

Elizabeth Fly, coastal climate extension specialist with the S.C. Sea Grant Extension Program, organized and chaired a panel called "The Future of Shellfish Restoration in the Face of a Changing Climate."

Fly has followed trends of increasing ocean temperatures and shifting distributions of species as organisms adapt to warmer waters. One such organism is the bacterium *Vibrio parahaemolyticus*. Vibrios are saltwater bacteria that prefer warm water.

As the climate changes, scientists are seeing outbreaks of this vibrio in locations where they have never been previously documented, according to S.C. Sea Grant researcher Charles R. Lovell, a microbial ecologist at the University of South Carolina.

"We've been seeing major outbreaks of this organism at high latitudes since 1998," Lovell said, "and we continue to see them today. They are in places that historically have been considered too cold. The connection to global change is pretty obvious."

V. parahaemolyticus is the number-one cause of seafood-associated food poisoning. There are 4,500 cases estimated per year in United States.

"That's certainly an underestimate, because lots of cases go unreported," said Lovell. "Diarrhea [that you get from this pathogen] won't kill you, but you might wish it would."

Lovell and his colleagues are studying conditions under which a virulent strain of this bacterium would be magnified very rapidly and create a "hot" oyster.

"This pathogen is extremely fast-growing," said Lovell. "It has a doubling time as low as 8 minutes. *Escherichia coli (E. coli)*, which people think of as extremely fast-growing, has a doubling time of 20 minutes at best."

But what's the trigger that allows this vibrio to grow so quickly? It appears that the vibrio stresses the oyster's immune system. Lovell's research suggests that the vibrio attaches to the outer membrane tissue of the oyster and begins growing rapidly in population while also battering the oyster's

Students from the New York Harbor School participated in a panel session titled "Youth Engagement in Shellfish Restoration: Student Perspectives" during the 16th International Conference on Shellfish Restoration. The session was facilitated by Peter Malinowski (fourth from left), director of the Billion Oyster Project at the New York Harbor Foundation.
PHOTO/SUSAN FERRIS HILL/S.C. SEA GRANT CONSORTIUM

NEWS & NOTES

immune system. The vibrio in an immune-compromised oyster can grow without opposition and can outnumber all other organisms, growing to a size that creates a "hot" oyster.

For more information about this panel and to read abstracts of other presentations and posters, visit www.scseagrant.org/icsr.

S.C. graduate student selected for Knauss fellowship

Courtney Gerstenmaier
PHOTO/NOAA

Courtney Gerstenmaier was selected as a 2015 fellow for the prestigious John A. Knauss Marine Policy Fellowship. Nominated and supported by the S.C. Sea Grant Consortium, she was among 52 chosen from a pool of more than 100 candidates submitted by the nation's Sea Grant College Programs.

Gerstenmaier completed a M.S. in marine biology from the College of Charleston. As a Knauss fellow, she is serving as an ocean science educator/communications specialist for NOAA's National Marine Fisheries Service and the National Museum of Natural History (NMNH).

"I am pleased Courtney was selected for this year's class," said Rick DeVoe, executive director of the S.C. Sea Grant Consortium. "The Knauss Fellowship experience will greatly benefit her professional career, NOAA Fisheries, and NMNH."

In this newly created joint fellowship, Gerstenmaier is serving as a bridge between NOAA Fisheries and the NMNH. Currently she is recruiting NOAA scientists for the museum's "Expert is In" program and designing education activities on topics such as how climate change impacts, including ocean acidification, can affect fisheries. She also is creating a series of ocean-related events at the museum for young professionals. "I hope to increase my knowledge about the research that NOAA is conducting," said Gerstenmaier, "and how natural history museums can incorporate ocean science research in order to stay relevant with society's interests."

To further the education of future leaders, the National Sea Grant Office has sponsored the Knauss Fellowship program since 1979. The fellowship brings a select group of graduate students to the nation's capital, where they lend their scientific and policy expertise to federal agencies and congressional staff offices while learning about federal policy regarding marine and Great Lakes natural resources.

For more information about the John A. Knauss Marine Policy Fellowship, visit www.scseagrant.org/content/?cid=56 or contact Susannah Sheldon, program manager, at (843) 953-2078 or susannah.sheldon@scseagrant.org.

2014 S.C. Environmental Awareness Award call for nominations

The state of South Carolina is seeking nominations for an award to recognize individuals who are doing extraordinary work for the natural environment. Nominations will be accepted through June 12, 2015.

The S.C. Environmental Awareness Award, now in its 21st year, was established by the S.C. General Assembly during the 1992 legislative session to recognize outstanding contributions made toward the protection, conservation, and improvement of South Carolina's natural resources.

Each year the public is invited to submit nominations which are then reviewed by an awards committee. In judging nominees, the committee considers excellence in innovation, leadership, and accomplishments that influence positive changes affecting the natural environment.

Members of the awards committee represent the S.C. Forestry Commission, S.C. Department of Health and Environmental Control, S.C. Department of Natural Resources, and S.C. Sea Grant Consortium.

The 2013 Environmental Awareness Award winner Joseph R. Hamilton was honored for his efforts in wildlife conservation. He is the founder of the Quality Deer Management Association.

Nomination guidelines and application forms are available by contacting Barbara Neale at (843) 953-0245 or nealeb@dhec.sc.gov. A copy of the application form can be accessed at www.scdhec.gov/Agency/NewsReleases/2015/nr20150505-01.

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EBBS & FLOWS

National Marine Educators Association

Newport, Rhode Island
June 29-July 2, 2015

The National Marine Educators Association conference, hosted this year by the Southeastern New England Marine Educators, brings together formal and informal educators from around the world. The conference theme is "Ocean State, Ocean Planet: Exploring Our World of Water." Attendees will learn about current ocean exploration research and technology, innovative ocean literacy programs, and the next generation of science standards. For more information, visit www.marine-ed.org/general/custom.asp?page=NMEA_2015.

Coastal Structures and Solutions to Coastal Disasters Joint Conference

Boston, Massachusetts
September 9-11, 2015

The Coasts, Oceans, Rivers, and Ports Institute is hosting a multidisciplinary, technical specialty conference focused on resilient coastal communities. This conference will bring together professionals and practitioners from around the world to discuss lessons learned from recent coastal disasters, such as Hurricane Sandy and Typhoon Haiyan. Attendees will propose solutions to reduce future impacts of coastal hazards. Visit www.copricoastalconference.org for more information.

ASBPA National Coastal Conference

New Orleans, Louisiana
October 13-16, 2015

The American Shore and Beach Preservation Association (ASBPA) is organizing a conference to bring together practitioners, consultants, government agency representatives, and students to share and discuss best management practices in coastal management, science, policy, and technology. The theme is "Broadening Coastal Perspectives," and the conference is designed to educate attendees on the many interdisciplinary aspects of coastal management. For more information, visit www.asbpa.org/conferences/conf_fall_15.htm.

Subscriptions are free upon request by contacting: Annette.Dunmeyer@scseagrant.org

ATTENTION SCHOOL TEACHERS! The S.C. Sea Grant Consortium has designed supplemental classroom resources for this and past issues of *Coastal Heritage* magazine. *Coastal Heritage Curriculum Connection*, written for K-12 educators and their students, is aligned with the South Carolina state standards for the appropriate grade levels. Includes standards-based inquiry questions to lead students through explorations of the topic discussed. *Curriculum Connection* is available online at www.scseagrant.org/education.